REMOTE MONITORING OF DAILY ACTIVITIES AND BEHAVIORS AT HOME

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***Abstract*-In maintaining the health of people, both elderly and younger, it can be useful to monitor their health status through their daily routines in their own home. This paper reports on the remote monitoring of the daily routine behaviors in an ordinary house. We attempted to monitor the daily behaviors of a subject, mainly in the kitchen and dining room. Several sensors were installed, including infrared sensors to detect human movement, magnetic switches to detect the opening and closing of doors, a carbon dioxide sensor to detect presence of the subject, and temperature sensors at the kitchen sink to detect cooking. A 31-year-old man who lived alone was monitored for about three months. The output of sensors was recorded on a personal computer and the data were transferred to another site by the Internet. Monitoring was performed fully automatically. As a result, daily habits could be clearly identified. Such monitoring can contribute to the maintenance of health.**

***Keywords* – Health monitoring at home, remote monitoring, automatic monitoring**

I. INTRODUCTION

In maintaining the general health of people, it can be useful to remotely monitor their health status through their daily lives [1], [2], [3], [5]. Health management is enhanced if this can be achieved with fully automated procedures. This paper reports on monitoring daily activities by using sensors attached to house furnishings and fittings. This method is limited in that only activities in the home can be monitored. Its strength is that monitoring can be achieved automatically without placing any requirements on the subject (e.g. electrodes, cuff). If we wish to monitor people without burdening them with the process, the development of automated monitoring systems within the home presents a significant challenge.

II. Method

A. Monitoring System

The monitoring system was designed to work without any human operation during monitoring periods. The system included a notebook-type personal computer, several sensors, amplifiers, and an ISDN modem. In the current system, Microsoft Windows 98 was used as the operating system. The system consisted of three parts: data acquisition, data transfer and clock setting.

1) Data acquisition

Several sensors were chosen for monitoring daily behavior. The selected sensors were easy to place and use. The following sensors were selected:

1. An infrared sensor was used to detect human motion.
2. A magnetic switch was used for detecting the opening and closing of the door.
3. A CO_2 sensor was used for detecting whether the subject was present in the room, by monitoring the carbon dioxide expired.
4. Touch detectors were installed onto furniture and appliances. These produced an output when the subject touched the detector electrode.
5. A humidity sensor and room temperature sensor were used for monitoring environmental parameters.
6. A thermistor was installed in the drainpipe of the kitchen sink for detecting use of the kitchen.

Sensor outputs were collected with the monitoring program by a notebook-type personal computer that had A/D converters with 12-bit precision and digital I/O ports. The monitoring program was made with LabView (National Instruments).

2) Data transfer

To achieve remote monitoring, the data were automatically transferred to the host computer once a day via the Internet by using ISDN. The host computer was located at the Institute for

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Abstract

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Biomaterials and Bioengineering, Tokyo Medical and Dental University. To shorten the transfer time, the data were compressed before transfer.

3) Clock setting

Over a long period, the clock in the computer accumulates errors. These timing errors in the monitoring system could not be ignored. The monitoring program automatically connected to an SNTP (Simple Network Time Protocol) server each day to adjust the clock in the notebook computer.

B. Experiment

A 31-year-old man who lived alone was selected for a monitoring experiment. Sensors were installed in his home in the kitchen and dining room and at the main door, to monitor the behaviors of cooking, eating, and entering and leaving the house. Using this system, the subject was monitored from 4 Sep 2000 to 8 Oct 2000 and from 26 Oct 2000 to 15 Dec 2000 (86 days in total). Because the subject was absent from 9 Oct 2000 to 25 Oct 2000, the experiment was suspended.

III. Results and Discussion

Data were collected automatically during the experiment, and the transfer was successful every day. On 15 Dec 2000, the personal computer stopped and the experiment was finished. The cause of the computer stopping may have been due to instability of the Microsoft Windows 98 operating system in long-term operation. The next version will use the LINUX or Microsoft Windows 2000 operating system.

From Fig. 1, it is easy to estimate that some daily behaviors can be observed from the sensor outputs. By comparing outputs with a behavioral record, after the subject woke up a high rate of sensor outputs was observed until the subject went out. When the subject cooked, sensors installed in the microwave oven , ventilator, refrigerator, ovens and rice cooker provided output. At about 8 p.m., the kitchen drain temperature clearly increased, which may indicate washing dishes after supper.

As an example, Fig. 2 shows the output from the main door-opening sensor during the experiment. It is clear that the main door was opened between about 9 a.m. and 10 a.m. and between about 8 p.m. and 11 p.m. on weekdays. On the other hand, the pattern of the main door opening was clearly different on holidays compared with weekdays.

Fig. 3 shows the output from the CO_2 sensor. A periodic pattern was observed in the output of CO_2 due to breathing of the subject. Combining the opening of the main door and CO_2 output allows estimation of whether the subject was absent [4], [6].

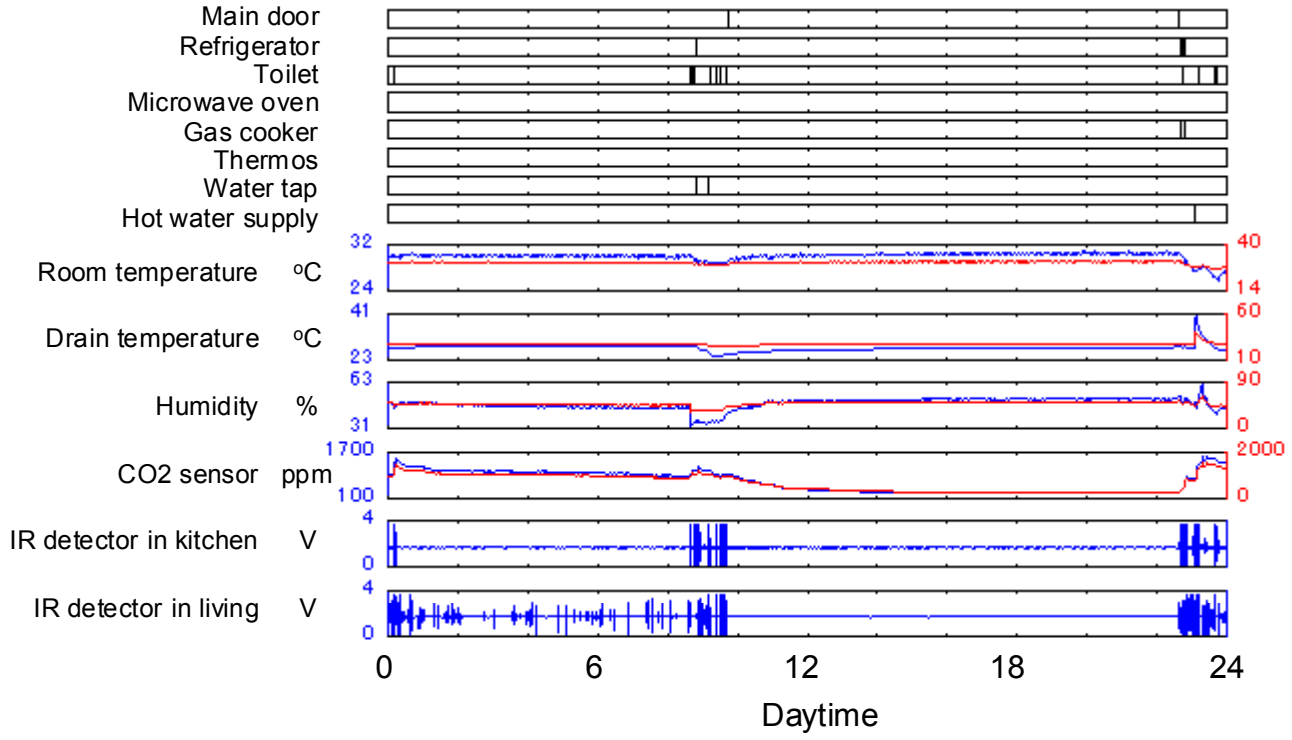

Fig.1 Data obtained from the sensors for a typical day

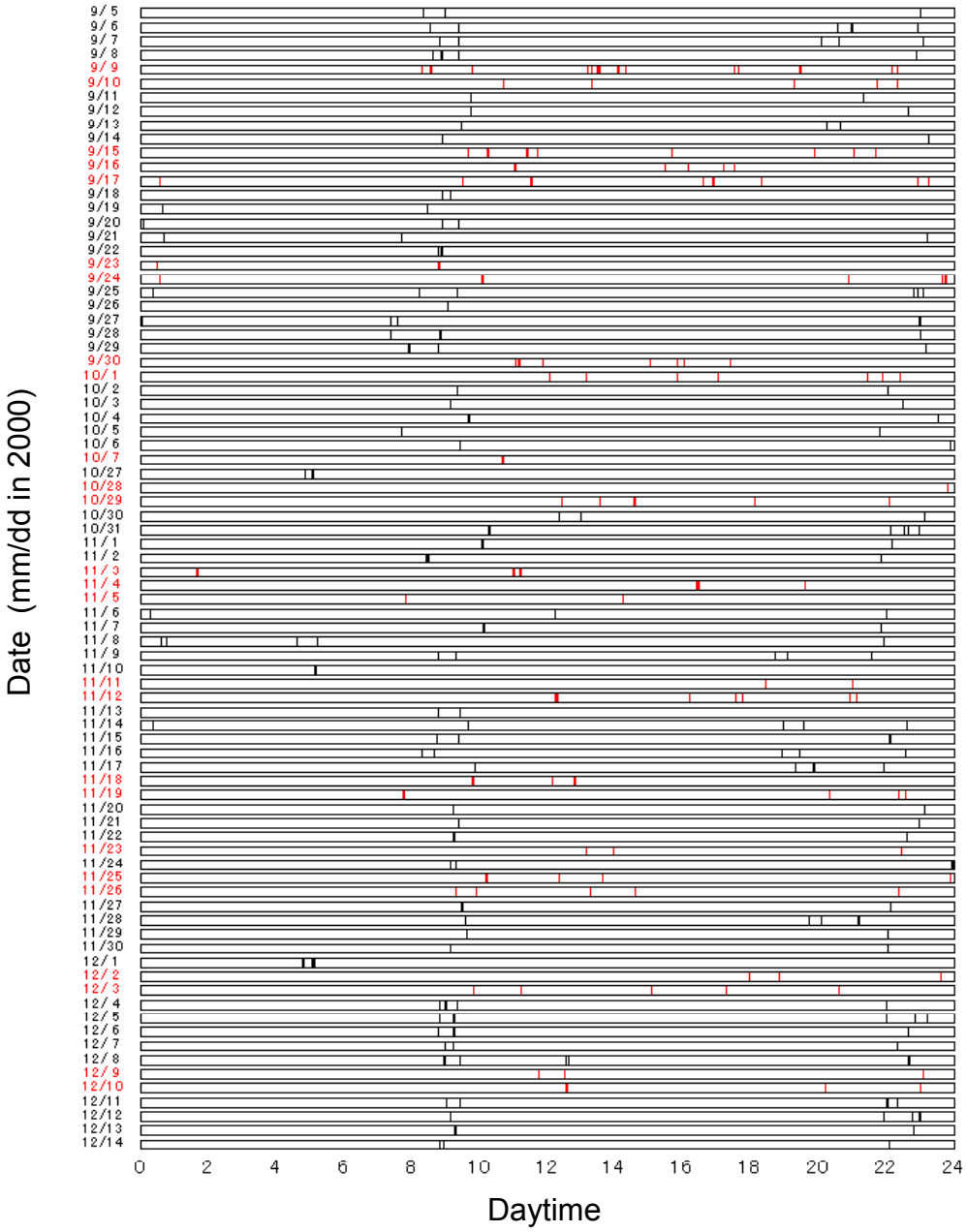

Fig.2 Output from door opening sensor during the experiment (for 86 days).

Vertical bars indicate door openings. Black bars show openings on weekdays, red bars show openings on holidays.

IV. Conclusion

Several simple sensors were selected and a data acquisition system was designed for monitoring daily behaviors. In addition, to achieve remote monitoring, the data were transferred to another host through the Internet via ISDN. To prevent large errors in the clock installed in the monitoring system, the system could reset the clock through the Internet.

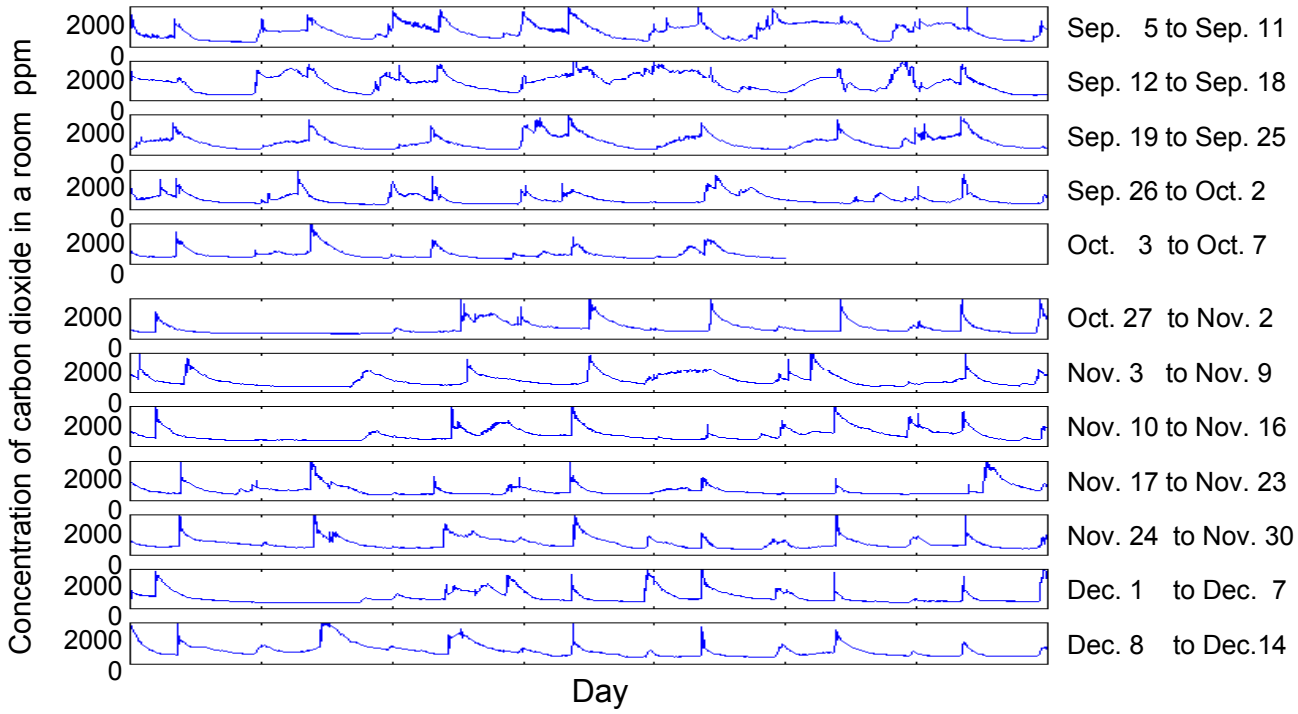

Fig.3 Concentration of CO_2 during the experiment.

Monitoring was evaluated practically with experiments in an ordinary house in which the subject lived. Data originating from daily behaviors were obtained fully automatically from a remote location. Some of the daily behaviors, mainly related to meals, could be recognized from the data. Such monitoring can contribute to the maintenance of health of people, both elderly and younger.

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